

A Potential NASA Research Reactor to Support NTR Development

Michael Eades*, Harold Gerrish**, Leroy Hardin***

**The Ohio State University, 201 W. 19th Avenue,
Columbus, OH, 35812, USA (email: eades.15@osu.edu)*

*** National Aeronautics and Space Administration, MSFC-ER20,
MSFC, AL 35812, USA (email: harold.p.gerrish@nasa.gov)*

****U.S. Nuclear Regulatory Commission, RES/DE/ICEEB MS: CSB-02A07M,
Washington, DC 20555-0001, USA (e-mail: leroy.hardin@nrc.gov)*

INTRODUCTION

In support of efforts for research into the design and development of a man rated Nuclear Thermal Rocket (NTR) engine, the National Aeronautics and Space Administration (NASA), Marshall Space Flight Center (MSFC), is evaluating the potential for building a Nuclear Regulatory Commission (NRC) licensed research reactor [1]. The proposed reactor would be licensed by NASA and operated jointly by NASA and university partners. The purpose of this reactor would be to perform further research into the technologies and systems needed for a successful NTR project and promote nuclear training and education.

PURPOSE

A successful NTR system is vital to NASA's ability to safely accomplish a manned Mars mission in the 2030s timeframe. In addition, many other space missions would benefit greatly from NTR capabilities. The proposed research reactor would support research, testing and training related to NASA's NTR efforts.

Specifically, the proposed reactor would assist in NASA's NTR development in five key ways:

1. The proposed research reactor would be able to demonstrate the integrity of NTR fuel and the retaining of fission products in a characteristic nuclear, thermal and corrosive environment.
2. A research reactor is a relatively low cost but important step towards a full scale NTR test. Designing, building and managing a research reactor similar to an NTR would inevitably result in lessons learned and invaluable technical and regulatory experience that would aid in NTR development.
3. A NASA research reactor supporting NTR development would help familiarize the personnel and management with nuclear systems. This could possibly streamline future NTR ground testing and reduce risk in schedule.

4. A man rated NTR requires more extensive data on radiation damage effects on materials than is available in the current literature. The potential research reactor could provide the facilities needed to generate radiation damage data. Furthermore the radiation environment provided by the proposed research reactor would likely be more similar to the NTR radiation environment than the radiation environment provided by common light water research reactors.
5. The potential research reactor would have a similar neutronic environment to a low enriched uranium tungsten cermet NTR and would be a good benchmark for codes modeling a full scale NTR. This benchmarking would decrease uncertainty in the design of a full scale NTR test.

In addition, the potential research reactor would provide a unique research reactor for use by affiliated universities and other interested users. This effort would be owned and managed by NASA and operated by NASA and affiliated universities. Licensing would occur through the NRC.

PROPOSED DESIGN

Discussions on characteristics of this potential reactor are currently ongoing but it is expected that any final design would use and test a number of NTR technologies. Central to these design discussions is cermet fuel similar to that being developed for NTRs. This fuel is a mix of 40% W and 60% stabilized UO_2 [2]. Fuel elements are approximately 1 inch diameter each and would be interspersed in a ZrH_2 moderator. A Be reflector would also be utilized. Flux traps, neutron beams and other science facilities would also be incorporated for academic research.

Maximum thermal power of the reactor is expected to be limited to no greater than 10 MW and would use low enriched uranium. The duration of runs and total fuel burn up would be minimized to reduce the potential for fuel failure and fission product inventory.

Cooling would be provided by hydrogen or helium flowing through small axial coolant channels in the moderator and fuel.

Other variations being considered include dual reactor cores operated from a single control room. This would allow for both short term operational use as well as extended duration operations simultaneously.

FUEL ELEMENT DEVELOPMENT

Significant testing of prototypical fuel element assemblies with natural uranium would be performed at MSFC's Nuclear Thermal Rocket Element Environmental Simulator (NTREES) facility prior to operational use of the fuel element design at the NASA research reactor [3]. While extensive monitoring capabilities to measure particulate and gaseous releases to the environment would be inherent to the design, other proactive design features and processes are planned to reduce the risk to a negligible level.

PLANNED SCHEDULE

NASA intends to begin engaging the NRC in pre-application discussions regarding this concept beginning in the 4th Quarter of FY 13. The purpose of these discussions would be to identify any special areas of concern and to support the development of a quality application to support an efficient, effective and timely review by the NRC.

The design and licensing of any additional facilities to support the operation of this reactor (to include hot-cells for system evaluation) would be included in this application. Any required support for transportation of fresh or used fuel (to include reactor component assemblies) would be addressed through interaction with and application to the NRC's Office of Nuclear Material Safety and Safeguards (NMSS).

If a decision is made to proceed, the expected timeframe of submission of this application would be the first quarter of FY15. This date is subject to change due to budgetary and programmatic developments.

CONCLUSION

This proposed research reactor would provide a valuable asset to NASA's effort to develop and fly an NTR for manned Martian exploration. In addition, this reactor would provide an invaluable research asset to affiliated universities.

REFERENCES

1. NASA, Draft Letter of Intent for NASA Research Reactor (2013)

2. R. HICKMAN, B. PANDA, S. SANDEEP "Fabrication of High Temperature Cermet Materials for Nuclear Thermal Propulsion," *Joint Army Navy Nasa Air Force (JANNAF) Propulsion Meeting (JPM) and 2nd Liquid Propulsion/ 1st Spacecraft Propulsion Subcommittee Meeting*, Monterey, CA, December 5-8, (2005)
3. W. J. EMRICH, "Nuclear Thermal Rocket Element Environmental Simulator (NTREES)," *25th Symposium on Space Nuclear Power and Propulsion*, Albuquerque, NM, 10-14 February, Vol. 969, p. 541-548, AIP Conference (2008)

DISCLAIMER

This paper represents the personal opinions and viewpoints of the authors. Although the authors may be employees of the NRC or NASA, the NRC and NASA express no opinion whatsoever either in support of, or in opposition to, the contents of this paper. The NRC and NASA support the efforts of the authors in the preparation and publication of this paper in the interest of fostering discussion and of the broad promulgation of ideas, but do not endorse the ideas themselves. Reference to this paper is not a sufficient basis for establishing the acceptability of any proposed system, and will not be accepted as an adequate justification or technical explanation in any licensing application. Applicants and licensees who wish to adopt any of the ideas presented herein will need to provide their own justifications and demonstrations of suitability.